A Concept of an Interactive Controlled Vertical Blind

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THESIS PROJECT
Bachelor program in Interaction design
A Concept of an Interactive Controlled Vertical Blind

Abstract

One of the most common devices found worldwide in today’s society, is the curtain in various designs. Different designs which require different types of physical efforts to be used and adjusted to achieve the intended purpose.

Due to lack of features in a regular vertical blind and its construction, it makes it hard to use and apply with normal behaviours of the human. Where the basic idea is based on a static design with a parallel relationship between the individual vertical blinds is the prototype based on individual movements of the blinds. A static relationship, which requires repeated adjustment through the day and the movement of the sun to achieve the desirable functionality. However, when the user gets interrupted and distracted for example at work repeatedly during a complete day, his or her performance and creativity at work will be reduced.

In this paper I have chosen to focus on the interaction design of the vertical blind and how to improve the interaction relationship between it and the user. Also showing how it is possible to create solutions for a simple and common unit like a vertical blind, by means of interactive models, use cases, technical predictions and a proposal of a future GUI that makes it possible to implement the models in a prototype of an embedded system.
Sammanfattning

I dagens samhälle är en utav de mest förekommande inrättningarna gardinen, i diverse utföranden. Olika utföranden som kräver olika typer av fysiska prestationer för att användas och anpassas efter önskat behov. Dessa fysiska principer är dock inte applicerbara i alla utrymmen där funktionaliteten hos en gardin kan tänkas behövas, då användaren själv måste utföra fysiska prestationer för att använda den monterade enheten.

Då grundidén hos en lamellgardin är baserad på en statisk design där samtliga lameller är sammankopplade i en parallell relation, är konceptet baserat på möjligheterna som uppstår vid en friläggning av lamellerna, vilket i sin tur låter dem röra sig fritt och individuellt kring sin egen axel. Det statiska förhållande som råder mellan samtliga lameller i det ursprungliga utförandet, gör det svårt att få en vidhållen funktionalitet som lämpar sig tillsammans med ett mänskligt beteende och rörelsemönster, eftersom lamellerna måste ställas in återupprepade gånger under dagens gång. Då den tänkta användaren återupprepade gånger under dagen blir distraherad, på till exempel sin arbetsplats på grund av det behov som finns för att anpassa lamellernas vridning för önskad funktionalitet, kan dennes koncentration och produktivitet påverkas negativt.

I kandidatavhandlingen har jag valt att fokusera på interaktionen mellan människan, den fysiska gardinen och möjligheterna att förbättra interaktionsprinciperna mellan dem för att göra användarupplevelsen mer anpassad efter användarens behov. Den presenterar även möjliga tillämpningar av den ursprungliga lamellgardinen med hjälp av interaktionsmodeller, användarscenarios, tekniska förutsättningar och förslag på ett eventuellt gränssnitt för konceptet som gör en framtida implementation möjlig som del i ett inbyggt system.
A Concept of an Interactive Controlled Vertical Blind

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Index Terms—Concept, GUI, Interaction, Interactive, Prototype

I. INTRODUCTION

Curtains have always been a way for humans to prevent themselves from insight, block bright daylight and direct sunlight, but also as a decoration in their homes. The human (the user), has always been forced to control and adjust the curtain manually to receive its purpose, a purpose that will change minute by minute upon the users dependency, but also the actual weather situation on the outside related to the indoor environment in some cases. A sunny day when it is warm outdoors, simultaneously as a user possibly wish to obtain the light from the sun but not the direct sunlight and heat produced. In a second occurrence, the user possibly wants to obtain the clear sunbeams instead, to reach a comfortable temperature in the area. Secondary use for a curtain is the contributed privacy.

Common ways to interact with a curtain are a string (or strings) attached, a simple interaction that demands varying kinds of physical conditions like length, which is not executable for all types of users in the wide society. Strength, body structure or any kind of disability should not prevent the user from using a common service like shading in everyday life.

As curtains are generally found in different designs, separately developed to block the sunlight with different solutions by using their individual techniques, are non of those designs a complete replacement to a previous one. The basic purpose remains, as the principles to achieve such a vision to block and shade a specified area changes. The mutual properties to operate all of these designs are the manual operation modes to adjust the device frequently, were in some cases not all users are possible to perform by their own.

The hypothesis for this problem is to create an adaptive creative solution. In a way were the unspecified user can achieve a clear view of the outside environment while moving around in front of the window, but still remain the surrounding shading of the remaining sections of the room. Also to have the additional possibility to be located anywhere in the operational area obtaining shading functionality if desired, simultaneously as the remaining surroundings remains illuminated by the sun for free. These features along with a user friendly interaction and energy efficiency in the view of an environmental friendly perspective, to achieve an easier life style for the conventional user. The question to put is therefore; is it possible that a simple thing like a curtain could be used to interact and automatically maintain a predetermined relation between, both the user and the current weather situation?

The main objective is to create new improved interaction models for vertical blinds, which enhance automated usability and make it more adaptive. These models are the basis of implementation that will be performed by Eric Lind.

II. BACKGROUND

During a day at work when the sun is moving from east to west the workspace is hit by sunlight, from an accommodative incidence angles that will change during the day. Duration is related to current location on earth and time of year, caused by the obliquity of earth. To prevent glaring and interruption of affected users located in the room, a vertical blind is used to shade of the area. The problem that emerges is the current adjustment of the blinds, it will supply the current situation, but in a moment it will be impaired until vanished. Profits of the vertical blinds are that remaining workspace will be lit
simultaneously as the desired area will be shaded. If blinds are set to a complete shade, the room will not be illuminated at all and additional light sources will be needed to light the room, which is not energy efficient at all when resources of the sun are completely free of charge.

An inverted situation in the very same workspace is when a user stands up and starts to move freely in the room to look outside and get a great view. The first thing to do is either completely pull aside the blinds or adjust them into position to create a clear view. A clear view that will be impaired until vanished based on the same principles as seen in the shade functionality, but inverted. When pulled aside, resulting in an empty window, all functionally of shading will also be vanished.

Possible occasions where the functionality can be used are in situations where the possible user has got needs for daylight, but is sensitive to direct sunlight due personal circumstances. For instance found in hospitals among others during medication and rehabilitation. In situations like previous mentioned, is not a physical demanding product efficient (or functional at all). If brought to an automated interactive design instead, the situation would be relieved and eases a lot of additional work considering constant adjustments needed to maintain the required condition.

The concept inspired by these issues has to be able to at least resolve the announced situations and bring the functionality to a conventional use. A concept of an interactive controlled vertical blind that can manage to track the user when moving around and adjust each of the blinds individually to shape a clear view related to the current positioning. Also to track the movement of the sun during a day to shade of specific areas, but maintain the illumination of the resources produced by the sun for free. Functionality is divided into separate layers controlled and prioritized by the user to achieve the desirable support and overlap each other when finalized or out of functionality.

The general problem among all existing designs concerning different curtains is that none of them meets the demands of all purposes and desirable functions that society may want. Whether it is a partly shading or a complete sun block that is provided, but how to merge multiple designs and functions?

III. HISTORY

Where strings are the oldest and most reliable way to utilize the proven functions, aside from manual movement of the complete construction, are they still dependable and functional restricted. When operating and adjusting each of the devices, the issue that remains, is the labor intensive executing. An issue that has been physically succeeded to ease the interaction between the user and the device, by adopting servo motors in advance. Resulting in an easier way to interact where the physical demands partially becomes eliminated compared to the basic design. Featured as a two-way button (or two separate buttons) each controlling the motor in opposite direction, to either roll up or roll down to shade when for instance applied on a roller blind. The negative angle of this feature is the non-responding feedback of reached limits while operating, compared to the immediate response during manual operation. Either solved by a limited operation range or a secured construction to prevent malfunction, otherwise resulting in broken device. Further additions applied like remote controls and informative displays are also common, based on the servo motor feature to be efficient. A remote allows the user to adjust the roller blind remotely from a distance workspace or sofa, simultaneously as a display brings the usability ever further. Where a remote adds the possibilities to adjust the device within sight supervised, the extended display allows the user to indirectly interact with the device when out of sight. Around the corner or even further remotely, depending on the configuration of the system.

A connected display has got the possibilities to deliver and display the current status of the operation mode for several devices at the same time. Especially functional in bigger systems containing multiple devices in a larger spread, where individual devices are out of sight and linked simultaneous. Disorders produced by this feature are though the multiple input modes, when operating a large number of devices remotely from a linked location. Lately simplified using a touch screen instead of a huge panel containing an unfamiliar number of buttons and levers, to operate the unknown number of devices. Issues still remains concerning the continuously need for adjusting around the clock to achieve the intended function and efficiency.

In advance to create a prototype for solving the problem, the approach has to be reversed. Instead of using the previous relation in the interaction between the user and the device, where it is the user that has to adjust and perform the actions to achieve any adapted functionality, why not apply the responsibility onto the device instead? A device suited for everyone, in all kinds of environments without a single manual adjustment when configured. A device that is connected to the ambience of the intelligent home with rest of its elements, enabled for monitoring anytime, anywhere.

The principles to create and fulfill most of the functions are adjustments preformed from a distance, without any physical influence available for everyone.

IV. RELATED WORK

Within technical constructions and interaction design, are the types of solutions available in quite similar terms of interaction. A device that is improved with an engine that eliminates the labor-intensive interaction process, which previous was needed for usage. Related to authorized users in possible cases, are the automated processes a valued upgrade that eases usage of a product. Simultaneous as the unauthorized users or factors such as babies, animals or weather incidents denies access to interact.

A. Somfy System Inc.

The concept of a shade device controlled by a motor and automatic is not a new feature. Since the early designs of the manually operated awnings, the process is to manually adjust
the device. An interaction that makes the user unhappy with the functionality of the product, both in the process to use it and the result of the final product, will not make the user satisfied.

Attempts to solve the issues has been made by a numerous of companies during year of evolution, with similar prosperity in the different designs available. Solutions and advancements to increase the operation modes to the concept of shading have been made by Somfy System Inc. [1] among others. A basic additional solution of an awning is the retractable awning, which is constructed by a sensor and a motor for operational support. The sensor identifies the current climate condition of the room (or specified area applied to), which shades off the complete area immediately when interfering with sunlight, if activated.

Additional options on outdoors devices include a wind and rain sensor that disables the complete construction in case of risks for destruction, to eliminate device errors. In a relation to the user, this is a very useful property that does not make sudden movements and prevent incidents. Compared to the original concept where the user had to interact with the device mechanically, is the improved concept by Somfy System Inc. a confident successor that reliefs the usage and interaction of the device. The limitations are thereby not limited to the available strength possessed by the user, neither the physics.

Different designs and technical solutions provide additional peripherals such as remote controls and suited sensors for the specific case, which increases possible usage scenarios among wider groups of users. A simple thing like unneeded movements during relaxing or social conversations, compensated by a simple remote action. Use of a remote eliminates outside operation during cold weather or special circumstances like a skyscraper, where it is not possible or unwanted to interact directly with an integrated component, such as a control panel to operate the device.

This device creates a relation between both the user and the current weather situation, to either shade of a specified area using the sensor normally located in the windowsill or the one integrated in the construction. Possible operation is also available though a system timer or a manual remote control, in addition to the sensor based operation controlled by rain, wind and sunshine.

A limitation of the above approaches of interaction in relation between the concerning components, is the fact that there is no direct connection to the positioning of the user. The idea introduced by Somfy has an interactive approach connected to the current weather situation along with an indirect connection to the user, forced to operate manually using a remote. Still improved to disregard the labor intensive needs to operate the construction, but not a complete interactive device to work fully automated in an active environment.

B. Smart Windows

The Smart windows, also called switchable glass, are a fairly recent adaptable technique used in collaboration with glass or assorted types of plastic. Based on three different principles[2, 3], which can be used to give a clear window a two-dimensional aspect, clear and transparent or complete opaque vision.

One of the most common techniques for commercial use is the Electrochromic devices (ECD) as it is totally transparent when no voltage is applied, compared to the Suspended Particle Devices (SPD) and Liquid Crystal Devices (LCD), which requires voltage for maintaining transparent. Important properties of the ECD are the power consuming operation to change the current state of the glass. Were it only requires electricity to change the current state but not maintain, compared to the other techniques which requires a constant flow of electricity.

Advantages of a regular roller blind are the instant change when electricity is added or removed from the laminated film located between the glasses. As the current techniques only supplies absolute states (on and off), are no partial states available such as 50 per cent transparency. The only possibilities to obtain partially opaque on the applied areas are by sectioning the area into linear pattern sections, as the technique is constructed in arrays.

Adaptations for the switchable glass are found in public workspaces, as seen in glass-encrusted offices, conference rooms and the operators cabin in trains. Features of the glass are that the shielded area will not be totally shaded due the light absorption by the film, resulting in an illuminated misted glass instead of a solid surface produced by a curtain.

Even though, a clear glass has its advantages over the unique properties found in the switchable glass. These techniques would not work during a power outage, which would possibly put all of the different types in the opaque state, resulting in a solid wall without any possibilities to communicate during an evacuation or special incident. A useful feature, but dangerous if applied in an inappropriate application.

C. Kinect

The webcam-style add-on peripheral Kinect1, is a motion controller for the Xbox 360 released in 2010 [4]. The peripheral makes it possible for the users to interact with the console without a physical gamepad. With the camera specially developed to interpret a 3D scene of the current area, is it possible to digitally recreate the positioning of moving objects in real time when playing videogames. The functionality of the technology makes it possible for the user itself to be captured in 3D video data and control the characters smoothly in the digital videogame with direct interaction.

Despite that Kinect is a developed peripheral to the Xbox 360, is it possible to use the indented functionality of the device in third party development projects [5].

D. Basic Designs

Each specific design of existing indoor curtains has its own kinds of principles to bring shade to a restricted area, developed through varying needs. The most basic design is the

1Kinect™ is a registered trademark by Microsoft® Inc.
total sun block out, a blanket or a solid piece of material is covering the window or the sun’s entrance completely, in variety with partly blocking. These principles are still used in different applications such as regular curtains hanging on the sides of a window, similar to the ones found in a cinema or a shower, which are slideable along a pole where the curtain itself is attached (see fig. 1). A low-end design which requires all of the modifications and adjustments to be performed manually.

Linear blinds, the venetian blind, are often found integrated between the glasses in the construction of the window or in a narrow configuration. These blind designs are three dimensional-like designs compared to the two-dimensional roller design. Where the roller blind shades the area completely, is it possible to partly shade the area with the blinds (see fig. 3).

An addition to the indoor curtains is the awning, a mechanical outdoor shade, which is mounted outdoors. The awning is similar to the roller blind design, besides the working range and angle of operation. Compared to the linear and non-fixed design used in the roller blind is the awning fixed completely to slide out by an assisting frame, a design that serves both as an outdoor and an indoor device.

Materials in all of the previous design are differential between fabrics in transparency from absent to solid, coated and uncoated, also net and varieties of plastic. The functionality is still the same, shading in several conductions.

V. PROJECT DESCRIPTION

This concept is originally an elaborated idea by Eric Lind, but halted due lack of time and possibilities to develop further. The project was reassumed in 2010 when we were joined in the project to continue the development of the current process. Recasting of the idea was processed in two different angles of approach; software engineering participated by Interaction design.

Where the first idea only did involve a single person to be tracked, the system only had a single point to relate and justify to. A basic interaction model that recognizes a human ahead of a plant, pet or baby for example. People based on certain height, which can be specified in the system settings, is recognized and people and objects outside specification will thereby be ignored by the system. The blinds should adjust instantly, when initiated, each of the short sides to supply a clear view in relation to the traction point of the user.

Reinitiated when the user moves around in the restricted area, limited by the traction device utilized and automatically adjusted blinds, performed by servomotors until the user exits the area and triggering a system hold. In a real life situation is
this not a very common occurrence when multiple people are moving around constantly in various environments, resulting in a malfunctioning idea (fig. 4).

Fig. 4 – People in movement

The thoughts that had to be solved were, “How about two users, which one to track?” followed directly by “What should happen when the user exits the recognition area?” Further elements to be included were the weather situations, illumination in the room, energy efficiency and data overflow. All of the functions were known to not to work simultaneously due to the basic construction, but if categorized and sorted into a layer of hierarchy, the functions should not interfere with each other.

A. Work Flow

During the continuation of the project E. Lind was focusing on implementing the technical solutions, while we were continuing to work on the interaction principles. Where the general functionality of the concept only did involve trace of a single point, was this the point of start to relate to when creating the concepts. The technical solutions by E. Lind where stated to remain at this point to create a functional prototype, the interaction models was developed further to future implementation.

As the separate work proceeded, all of the advancements were to be shared between the both contributors to adjust and evaluate the individual process.

VI. DEVELOPMENT OF A FIRST CONCEPT

The first idea initiated, a concept that tracks the user and automatically adjusts itself to achieve the best possible view. Accomplished by individual servomotors attached to each of the single blinds in the construction. Rotatable individually instead of the original design, where the blinds are controlled simultaneously in a parallel pattern. By tracking the user and create a moveable differential point that moves along with the movements of the user, each of the individual blinds will adjust to face the thin short side against the user. Executed with ambitions to achieve the least possible interference between the visual field of the user and the blinds.

By using this model for our continuously work and development, the general principles for the concept had been stated and a substratum to use separately.

A. Physical Demands

To be able to develop functional designs and interaction models of the Interactive Controlled Vertical Blind, principles such as physical demands among the possible users had to be studied. In which way a properly device should operate and relate to different objects and users, which might possible enter the recognition area and make a request for interaction.

Along the sketching phase there was a lot of studies concerning the way to interact with the ordinary design compared to the principles of the concept. How the different users use this kind of devices, worldwide, difference in age, length and physical shapes. How this type of perspective could interfere or change the way of interaction among other users simultaneously.

By looking at the definition “adult” and “child” to simulate the problem of different groups of users, whenever they should be specified and identified as an adult or a child by a chart of measurements, assuming these to have different privileges. The general problem is that a teenager or a child by measures could easily mistaken by a grown man or woman (possibly oppositeness), depending on hereditary factors. Therefore is not a general alignment possible to define an adult worldwide, neither to be set by regional or a non-accurate definition by minimum height for identification and recognition. The end user individually has to set the definition of an adult or a child manually to adjust the device properly.

Physical conditions around the world in the actual society is continuously changing, physical demands and the fact that the human culture is various. Different dimensionality in relation to height of the individual person is changing. These are two aspects that are flexible but defined to be calculated and predictable in a system configuration, accessible through the GUI to be modified. A disabled person and a mobility-impaired person is on the other hand a permanent issue. When not obtainable information is available, like when disabled or mobility-impaired, the situation becomes aggravated. Easy task like pressing a button or lever on a control panel, located on the wall in medium high level [6]. Without any preconditions to even be able to move around freely using a wheelchair, this becomes an impossible task. But with abilities to move limited parts of the body such as fingers and partial limbs, the only option is a remote controlled action that can be performed easily.

To evolve the basic interaction and phase out the needs for physical demanding interaction, the whole process has to be digitalized and automated. It is though an aggravated problem concerning the knowledge and experiences among the different user groups. The older groups, which are users in constant needs, are often the users who have not got the possibilities or strength to move freely owing to their old age. The principles are all good concerning the improvements of physical demands, but these types of users are often experiencing uncomfortable and intimidating feelings with new principles, which may cause problems. The significant measures are therefore to create an interaction design that makes all of the users comfortable with the usage, along with good response about the current state. An issue caused by
uncomfortable usage with fear of breaking something or performing the tasks incorrectly, has to be solved.

B. Possible Interactions

To specify the possible ideas for interactions to be implemented as interaction models, all of the ideas had to be gathered and analyzed to determine if the presented ideas are suitable modes or not for the current prototype. Additional and currently non-adaptation able ideas can be found in Future Work.

Mode 1: Basic principles of the original design of a vertical blind are the parallel operation mode, a mode that connects all the blinds together in parallel relation. When one of the blinds is adjusted, the rest will instantly be adjusted in the exact same way as well. In this thesis referred as “Static Parallel Mode”.

<table>
<thead>
<tr>
<th>Number of users:</th>
<th>Insignificant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precondition:</td>
<td>System standby in current mode</td>
</tr>
<tr>
<td>Input:</td>
<td>GUI, Remote</td>
</tr>
<tr>
<td>Action:</td>
<td>Manual input from user</td>
</tr>
<tr>
<td>Expected response:</td>
<td>Blinds are adjusting completely parallel in a 180-degree radius (0-180)</td>
</tr>
<tr>
<td>Post condition:</td>
<td>Blinds are halted until reinitiated or mode is changed.</td>
</tr>
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</table>

Mode 2: An addition to the Static Parallel Mode when the construction is equipped with servomotors is a “Static Positioning Mode”. Allowing each of the individual blind to be rotated and adjusted manually, unrelated to the remaining blinds.

<table>
<thead>
<tr>
<th>Number of users:</th>
<th>Insignificant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precondition:</td>
<td>System standby in current mode</td>
</tr>
<tr>
<td>Input:</td>
<td>GUI</td>
</tr>
<tr>
<td>Action:</td>
<td>Manual input from user</td>
</tr>
<tr>
<td>Expected response:</td>
<td>Blinds are adjusting individually in a 180-degree radius (0-180) through the system GUI</td>
</tr>
<tr>
<td>Post condition:</td>
<td>Blinds are halted until reinitiated or mode is changed.</td>
</tr>
</tbody>
</table>

Mode 3: By adjusting all of the blinds in a linear line to shape a complete piece of material, a “Black Out” is formed. The functionality is similar to a Venetian blind, but in vertical.

<table>
<thead>
<tr>
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<th>Insignificant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precondition:</td>
<td>System standby in current mode</td>
</tr>
<tr>
<td>Input:</td>
<td>Vision System</td>
</tr>
<tr>
<td>Action:</td>
<td>User movement</td>
</tr>
<tr>
<td>Expected response:</td>
<td>When initiated by human movement in recognition area, blinds are adjusting to face short side against the referential point achieved from Vision system.</td>
</tr>
<tr>
<td>Post condition:</td>
<td>System mode is active and tracking the referential point until traceable (user enters the area), or mode is changed.</td>
</tr>
</tbody>
</table>

Mode 4: Create the best possible view related to the positioning of the user, achieved by adjust each of the blinds individually. Facing the short side against the user to eliminate disorder in view.

<table>
<thead>
<tr>
<th>Number of users:</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precondition:</td>
<td>System standby in current mode</td>
</tr>
<tr>
<td>Input:</td>
<td>Vision System</td>
</tr>
<tr>
<td>Action:</td>
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</tr>
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<td>Post condition:</td>
<td>System mode is active and tracking the referential point until traceable (user enters the area), or mode is changed.</td>
</tr>
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</table>

Mode 5: In addition to the View Mode, which only can handle a single user, the “Multiuser View Mode” can handle multiple users. By dividing the number of blinds by the number of user in the area, each of the users will achieve its own blinds to shape a personal view.

<table>
<thead>
<tr>
<th>Number of users:</th>
<th>1+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precondition:</td>
<td>System standby in current mode</td>
</tr>
<tr>
<td>Input:</td>
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</tr>
<tr>
<td>Action:</td>
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</tr>
<tr>
<td>Expected response:</td>
<td>When initiated by human movement in recognition area, blinds are adjusting to face short side against the referential point achieved from Vision system.</td>
</tr>
<tr>
<td>Post condition:</td>
<td>System mode is active and keeps tracking the referential point until traceable (user enters the area), or mode is changed.</td>
</tr>
</tbody>
</table>

Mode 6: “Hide Mode”, the opposite of the view mode. Instead of shape a clear view related to the users positioning, the user becomes hidden and the blinds block the visual field.
Mode 6 – Hide Mode

| Number of users: | 1 |
| Precondition:   | System standby in current mode |
| Input:          | Vision System |
| Action:         | User movement |
| Expected response: | When initiated by human movement in recognition area, blinds are adjusting to face long side against the referential point achieved from Vision system. |
| Post condition: | System mode is active and tracking the referential point until untraceable (user leaves recognition area), or mode is changed. |

Mode 7: “Protection Mode”, a similar setup to the Hide Mode. The vision system traces the location of the current positioning of the user, which interacts with the system using a remote to lock the positioning. Long sides of the blinds are facing the position and any other movements in the area will not interrupt the adjustment.

Mode 9: “Shade Mode” the opposite of Follow Sun Mode. Follows the movements of the sun, with the task to prevent as much as possible sunlight to reach the room without shaping a complete line of blinds. This mode has the same setup as the View Mode, disregarded the user is replaced by the sun.

| Number of users: | Insignificant |
| Precondition:   | System standby in current mode |
| Input:          | Sun Vision System |
| Action:         | Suns movements |
| Expected response: | When initiated by the sun struck, the Sun Vision System determines the current positioning of the sun. The blinds will adjust to prevent as much as possible sunlight to reach the room. Achieved by adjust each of the long side of the blinds facing the suns incidence angle. |
| Post condition: | System mode is active and tracking the positioning of the sun until untraceable (sun dawn), or mode is changed. |

C. Analyze of the proposed interaction modes

The principles used to determine and analyze the proposed interaction modes, are based on the preconditions of material and regular use during a regular day at work or at home [7].

When analyzing the different modes in comparison to which functions are likely to be used on a daily basis and suitable in a first concept, hardware is the component of limitation. Therefore all of the ideas were analyzed and put into categorizes, instead of just sort each of them out and thrown in the dustbin. Were each of the ideas are based and evolved upon the general design with technical adaptations, none of the ideas seemed to be unreliable or corrupt to be used in a concept.

Different categorizes are presented as following, “Basic Modes”, “Advanced Modes” and “Additional Modes”. As the Basic Modes only uses direct interaction between the user and the system without any additional sensors or remote controlled actions. The Advanced Modes uses the profits from a remote to perform remote actions as a complement to the Basic Modes. Lastly, the Additional Modes are modes with the special needs of extra equipment such as additional sensors to provide functionality compared to the basic construction of the system.

1) Basic Modes

The first mode, the Static Parallel Mode, it has the exact same functionality as the basic design first engaged with the vertical blind construction. A complete set of blinds perfectly aligned in a parallel formation, adjusted simultaneously as seen in fig. 5. The different between the basic design and this mode is the wire, which links all of the blinds together to adjust them simultaneously. It has been replaced by the servo installed to provide additional functionality. The alignment
therefore has to be adjusted by the servos in advantage to the permanent wire. Using the system GUI or an additional remote to rotate the blinds in an angle between 0 to 180 degrees accomplishes adjustments. Actions are performed directly by the user input without any delays disregarding I/O latency.

Fig. 5 – Static Parallel Mode

Due to the proven functionality found in the basic design, the mode is validated and known for being used in a final concept, resulting in an excluded analysis.

The **Static Positioning Mode** has got the possibilities to adjust each of the blinds individually with the assistance of the servomotors. Supervised through the system GUI to survey the angle of each blind. Due the limited space on a display, only one blind can be adjusted at the time when selected (see fig. 6).

Fig. 6 – Static Positioning Mode

A non-functional mode, which does not provide any assisting functionality considering the basic design and in how it is used. With needs for a time consuming process to adjust each of the blind manually, the concept will become an overwhelming process to use instead of the assisted device it was designed to be. Disregarding the possibilities to black out a limited part of the room by align a percentage of the blinds in a linear line, while the remaining blinds can be adjusted in an optional alignment. This mode is not functional, rather a troublesome mode to use and requires a handful of time to adjust, which does not qualify to the final concept.

**Black Out Mode** is a basic mode to prevent as much as possible sunlight to interfere with the environmental located inside of the connected room. Can be adjusted in an instant to form a linear line to shape a complete piece of material (see fig. 7). In dependent of the chosen material used in the blinds, the final result can be varying, a result likely received by a roller blind to a more translucent application. Though the result is not a complete complement to the roller blind design, it is possible to seal every inch of the applied window, the functionality is not the primary mode of the concept. Positive effects are the possibilities to use the mode as a shielding with benefits such as maintained illumination, provided by the sun without any labor-intensive operation or additional equipment.

Fig. 7 – Black Out Mode

The **View Mode** is the main functionality of the concept, with the task to provide the user with the best possible view. When a user approaches the recognition area, restricted by applied Vision System, each of the blinds is initiated. By tracing the current positioning of the user approaching, the referential point made is used to identify the authorization of the user. To determinate whenever the user trying to interact is an unauthorized child or an authorized adult, using the personal settings established in the GUI [8]. Instantly when the user is validated, each of the blinds will be initiated to adjust individually related to current positioning of the user, system will remain halted if invalidated. By adjusting the blinds to face the short side of each blind against the user, none of the blinds will attended to each other, but create an individual relation to the users positioning. Resulting in a clear view performed by the possibilities provided by the functionality of servomotors (see fig. 8). Small interferences may appear in the visual field depend on the thickness of the material used in the blinds, but will remain insignificant in comparison to the Parallel Mode.

While the blinds are initiated, the Vision System will constantly trace the positioning of the user whenever moved or not to maintain the active observation of the area, to prevent any latency or delay if the user suddenly starts to move. The compliance of the system will remain and manage to trace adjust itself to a brisk walk performed by the user.
The additional **Multiuser View Mode** is based upon exact same principles as the View Mode with a multiple user input. The difference between the two modes is the management of the exceeded limit of one user, which allows multiple users to interact with the system, without cause of any system error.

When two authorized users are approaching the recognition area, two unrelated referential points are created to determine the positioning. Instead of adjust the blinds instantly, as in the single user mode, the distance between the two users is calculated to create a new pivot point between the users. This new point is used to split the operation range of the blinds into the specified number of users, to shape a personal view. The pivot point created divides the partitioning for a fair assignment of the blinds, instead of dividing the blinds in even halves as seen in fig. 9.

**Hide Mode** has the opposite functionality of the View Mode, with the principles to block the visual field of the user. To prevent the user moving around in the room to see anything out of the window, the long sides of the blinds are facing the referential point of the user. The same functionality is given to possible spectators from outside the window, withholding the inside user hidden. Positive feedback in comparison to the Black Out Mode is the maintained illumination of the room provided by the sun, which disregards the needs for additional light produced from inside the room. Though the principle is the same as a shield of the complete room, using the Hide Mode instead will save energy during daylight (see fig. 10).

2) **Additional Modes**

The **Protection Mode** is a static mode used to protect valuable items or users to be seen from the outside, likewise to see outside as the Hide Mode. The current positioning of the user can be locked using a remote to determine the correct positioning of a valuable item. When locked in positioning the Vision System stay paused and will not adjust at all if additional users are passing by the area in between the locked position and the window (fig. 11). The mode is useful if used in situation were spectators are passing by and valuable items are stored in the room, to prevent possible housebreakings. As the mode is shielding a position, it is applicable to use with items such as furniture and users sensitive to direct sunlight.

**Follow Sun Mode** traces the suns path during the day, using a Sun Vision System with the task to analyze and provide system with the current information of the suns movement. The information is used to adjust the blinds to maximize the sunshine to hit the room directly (fig. 12). The principles used is similar to the View Mode dispense with the facts that the sun is traced instead of a user to achieve its purpose, resulting in the least possible shading.
Shade Mode is the opposite mode of Follow Sun Mode with the task to maintain the applied room shaded (fig. 13). Positive effects are the exception of direct sunlight when working or entertaining with the indirect illumination of the room.

D. Layers

To make all of the modes useable instead of just state them as a pieces of different functionality, they had to be able to cooperate in a hierarchy-featured categorization to work in a relation between the desired modes. Exemplified when using the Follow Sun mode, the blinds are adjusting according to the sun, but do not take any notice of a potential user approaching. If the modes in the example were assembled to cooperate in layers based on hierarchy, the scenario is changed to work side by side as a complement to each other.

By placing the Follow Sun mode in a level two category in the layers succeeded by the View Mode located in level one, the blinds will follow the path of the sun during the complete day with the only one type interruption possible, the approach of a authorized user. The system will immediately validate the approached user, if verified correctly the View Mode will be initiated automatically without any further notice. Level one of the layers is only maintained as long as there is any activity provided to activate the specified mode, when unable to initiate any further is the level two mode reactivated. This process is iterated until any of the layers are adjusted or replaced by another.

These principles are based on two groups were the modes has been divided by properties and functionality to work together. As the layer principle has room for two modes to be set, some of the modes are only place able in layer one if a certain mode already is set to the second layer. The two different groups are interactive and secondary modes, were the interactive group contains the modes using the Vision System to trace the user.

Table I – Interactive Modes

<table>
<thead>
<tr>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>View Mode</td>
</tr>
<tr>
<td>Multiuser View Mode</td>
</tr>
<tr>
<td>Hide Mode</td>
</tr>
<tr>
<td>Protection Mode</td>
</tr>
</tbody>
</table>

The secondary modes are the modes that do not use Vision System to operate.

Table II – Secondary Modes

<table>
<thead>
<tr>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Parallel Mode</td>
</tr>
<tr>
<td>(Static Positioning Mode)</td>
</tr>
<tr>
<td>Black Out Mode</td>
</tr>
<tr>
<td>Follow Sun Mode</td>
</tr>
<tr>
<td>Shade Mode</td>
</tr>
</tbody>
</table>

All of the modes found in both of the groups can be assigned to level two, but if an interactive mode is placed in the first, a secondary is not place able in the first (see table I). If as preferred, a secondary mode is placed in the second level and a interactive mode is placed in the first level, the secondary mode can be operational at all times but interrupted by the Vision System to activate the interactive mode placed in the first layer (see table II).

Table III – Only one mode available for use

<table>
<thead>
<tr>
<th>Layer</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>View Mode</td>
</tr>
</tbody>
</table>

Table IV – A functional Hierarchy with two Modes

<table>
<thead>
<tr>
<th>Layer</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>View Mode</td>
</tr>
<tr>
<td>2</td>
<td>Follow Sun Mode</td>
</tr>
</tbody>
</table>

E. Graphical User Interface

In the development of the Interactive Controlled Vertical Blinds, there has to be some kind of GUI to select and administrate the interactive functionality provided with the system. With the knowledge of different input modes and understanding of the wide selection of possible users, a GUI had to suit the plurality of them, considering age, prior knowledge, disabilities and different context found around the sector of use.

By applying a touch screen interface to interact with the system, the issues concerning multiple input languages and labeled buttons becomes eliminated due to the unlimited possibilities to modify the interface. Using virtual touch buttons on the touch screen, which replaces hardware buttons, brings the possibilities to relocate different elements and buttons without replace the complete unit. With a unit processed without any operational buttons (buttons such as power not counted), it will immediately become more
adjustable to fit both novice and advance users and make them comfortable using the touch screen.

1) The Design
The design of the GUI is completely inspired by the swipe gestures used in the two large mobile operation systems Android™ and Apple® iOS to switch between different home screens. By using straight swipe gestures to operate the system with the assistance of a number of dots as an overview in the guidance of the GUI (see fig. 14), the system becomes more effective and easy to use. As the user operates through the different screens of modes is the current screen represented as a larger dot, these dots will always be visible if there are any screens available to slide through horizontally.

Fig. 14 – Home screen navigation dots

To inform the user of available screens vertically to adjust the current settings of the system, arrows will presented in the top and lower space of the current screen.

The structure of the GUI is based on a laying “T” model (base facing right) to be able to operate between the different screens, with the screens such as “Home screen”, “Layer screen”, “Fast modes” and Settings (see Appendix 1). The first screen to be introduced when boot sequence is finished is Home screen containing the current weather situation. By swiping upwards to access the lower screen containing the settings of the system, all information and units of measurements can be modified. When swiping in the opposite direction (downwards) in the Home screen, the Layer screen is accessed. The Layers screen contains two frames with the labels “Layer one” and “Layer two”, the frame located to the left is containing the second Layer (see fig. 15). The green arrow (in center) is an illustration pointing the frame with the higher priority to acknowledge the user to make a correct choice.

By tapping the frame labeled Layer one, the screen will fade out and show the modes available to choose from, in this case when Layer one is chosen is all of the available modes presented in a horizontal view with the assistance of the navigation dots (see Appendix 2). To make it easier to see which modes that are located to the right or left of the presented mode, a small piece of each is visible on both sides. When the desired mode is chosen, a confirmation bar rises from the bottom to inform the user to confirm its choice before applying the chosen mode (see fig. 16).

Fig. 16 – Confirmation of chosen mode

If the mode is confirmed, the picture will shrink and be fitted into the frame of choice, otherwise the screen will just revert the bar of confirmation to make it possible to re-choice another mode.

Relocated in the Layers screen, the user has to manually perform a swipe gesture upward to reach the Home screen once again. This manual action is kept to prevent any mistakes or indecisiveness of the user.

As an addition to the selection of the layers, some modes are reachable through the Fast modes by swiping right to left in the Home screen. The modes available in Fast modes are only the modes which does not require any further adjustments to use, such as View mode, Hide mode, Follow Sun mode and Shade mode. This setting is only temporary and will be replaced when initiating the Layers screen once again.

F. Energy Efficiency
Energy efficiency is an important section of the Interactive Controlled Vertical Blind (ICVB) concept due to the “smart” and “intelligent” house holding it meant to be able to be integrated with.

As monitoring of the power consuming elements in a modern home of today is an increasing phenomena with an incalculable number of sensors to supervise the house hold [9], heat and the current temperature of different zones is one of them. With the possibilities to be able to measure different temperatures in the climate zones a household is divided into, individual adjustments is possible to achieve or withhold the desired temperate preset. The positive effects with these kind of resources are the possible use and sync the ICVB with a monitoring system to set different modes during a day. Instead of increase the radiators in the zone during a sunny day when the temperature is to low compared to the preset temperature,
the Follow Sun Mode can be initiated to support the heating systems used and save energy.

The principles to use are the two modes related to the sun’s path, Follow Sun Mode and Shade Mode, to compensate the current temperature trying to obtain and serve better efficiency. With a regular behavior of a system that administrates a households climate zones, would a normal executing be to increase the output of installed equipment for heating or cooling. But with the ICVB connected in the system, the previous maintaining behavior will be changed to save energy. By setting the mode to Follow Sun Mode when the temperature is too low, it will assist the heating. In opposite situation, the Shade Mode can be initiated for as long as the process in active, when desired level is reached the mode will change back to previous mode set.

VII. Final Concepts

When choosing the features of the presented models for the final concept, the possible modes were analyzed a second time to determine the actual functionality in a real life situation. In which way they would operate, in which way they could be used, but most important if they were suited to operate at all in the way they were presented. With the purpose of create a assisting concept to relief the use of the regular designs found of curtain, the functionality had to work independent of any continuously user input performed manually and provide additional functionality.

By looking at the two interacting modes, View Mode and Multiuser View Mode, makes it possible to actually resolve the problem of switching between different modes with similar functionality. Where the single View Mode functionality can be used in the Multiuser View Mode, the purpose of having the single one will be unnecessary, therefore the multiple mode can be applied on both single users and multiple.

The principles of shaping a clear view in relation to the user (users) positioning can be used in beneficial purposes regarding the use cases possible during a regular day, with the decision in mind to make it useable to everyone despite the physical conditions available. The system does not need any prior knowledge to be used when set and can be used with the same conditions by different users, with one condition, the movement by your own. If movements are not available to be performed by a user, he or she can be placed in the room by assist with the maintained tractions to not exclude disabled or dysfunctional users.

Based on this argument the Multiuser View Mode can be used by anyone and is possible for implementation in the final concept.

Using the same setting of equipment used in the parallel mode and the Multiuser View Mode, the Hide Mode is highly applicable. Instead of assisting the user in a direct interaction by adjusting the blinds for a satisfaction use, possible usage provides the user with an unremarkable pattern of movement. The Hide Mode, which was called “Running Naked Mode” during the development process, brings opportunities to actually move and situate covered or just exercise in private without any risk of major observation. Due the construction and installation principles based on a vertical blind, do not the blind have any preconditions to protect the visual field completely, not even when Black Out Mode is initializing.

To be able to apply the Additional Modes to the concept additional equipment and accessories are needed, such as a remote and a sun sensor (Sun Vision System) to make them even functional.

The Follow Sun Mode and the Shade Mode has the same principles with the opposite functionality in a short summarize. Both of the modes can be used on daily basis to maintain a desired state in a particular room, to make the direct sunlight hit the environmental inside or prevent it as good as possible with retaining the positive effects of the free illumination. The modes are highly useable in both an office and a public area, just as they will in a home of a family without any requirements to adjust the blinds a single time during a complete day.

The Protection mode is most advanced mode to be used and is the only mode to require direct interaction provided with other inputs than only movements of the user. Considering the functionality brought by the mode is it only useful when protecting valued items rather than used as a live mode. A disabled or an injured sitting in a wheelchair, which is placed in front of a window by a nurse, may be sensitive to direct sunlight. A similar occasion is when a valuable item is permanently located in front of a window, such as a sofa or furniture sensitive to sunlight. By using the remote when positioned in front of the sensitive user or item, the vision system can be used to trace the correct point of traction. The principles can be of valued use if used by the right user or items due the facts of the unneeded adjustments.

This can be exemplified as a use case in a home for the elderly where people have special needs to live though the day, based on the knowledge of the different condition of the resident. Instead of having a nurse adjust each of the curtains multiple times during a day, the blinds only have to set once to serve the affected user.

As a first concept to be implemented, the functionality is based on what is actually possible to create with a single camera (the Vision System), with no further accessories. A partially implementation of the concept can be found in the Master’s thesis of E. Lind [8] with the Parallel and multiple version of the View Mode implemented.

A. Use Cases

As the whole concept of the interactive controller is built on the separate mode earlier provided to be functional and operate as automatically as possible to interact with a user unnoticed. By using layers to categorize the modes to work, the functions are more useable when layered as complements to each other then used individually.
In fig. 17 is the Follow Sun Mode activated in layer two to follow the sun's path, layer one has been assigned to the View Mode.

In the first stage does the room not contain any authorized user at all while the Follow Sun Mode is activated in layer two of the layer hierarchies, is the blinds only task to follow the sun’s path. In stage two when an authorized user is approaching the recognition area, is the mode set in the first layer activated to exercise its tasks. The blinds will automatically adjust to perform the View Mode located in the first layer. The presumed action to be performed when the users exits the area once again, is to reactivate the Follow Sun Mode to await another authorized to repeat the process if the settings in the layers is not changed.

In this case (fig. 18) where the second layer is set to Parallel Mode, the blinds will be adjusted in a parallel relation and stay static. An unauthorized user is approaching the recognition area, but the as the user is identified as unauthorized, nothing will happen and the blinds will stay intact. Later on an authorized user is approaching and identified as authorized, resulting in an initiation of the Hide Mode. When authorized user is leaving the area, the system will be reinitiated in the Parallel mode.

By using the functionality provided by the Layer functionality, there is possible to do a number of matches between the available modes, these do inform of normal use cases.

VIII. Validation

To validate the principles used in the use cases of the concept, five typical users were selected in a first setup of the basic functionality. The objectives to be studied were understandability, usability, accuracy and the quality of the system management based upon opinions of real life end users. The scope of the validation process was to see how the principles of the concept were actually working when applied in real life situations. Observed during predetermined circumstances, scenarios and with potential users to validate the actual functionality and to prove the advocated functionality of the concept in the paper with the comprehensions of a potential user. The graphical user interface is excluded in this validation process.

A. Participants

The selection of typical users is based upon a wide perspective of young and old participants with different backgrounds and education. A selection with the situation of the middle class featured by both the upper and lower class [10], combined with job assignments with direct, indirect or no relation at all to a sun protecting device. The process to select suitable participants for a validation was made by alternate potential users in the society. Citizens common in every eventuality, combined with the knowledge of a conventional overview of available assignments in relation to a sun protecting device used indoors. Citizens with assignments such as constructors and truck drivers which either works and spends his or hers complete day outdoors or inside a warehouse without any windows, are considered irrelevant due to the lack of a direct need for such a device.

- Assistant Nurse, female aged 20.
- Clothes Salesman, male aged 21.
- Network Technician, male aged 24.
- Housewife, female aged 51.
- Senior Citizen, former barber, female aged 78.

The main objectives of the validation process are to give the participants an insight of the concept, similar to an introduction given at an exhibition when a new product is first shown and not a complete lecture of the concept. The distinct differences are though the non-selling approach and a primary focus on the response of the user experiences emerged and expressed. The participants are informed, observed and analyzed individually in an enclosed space during the complete validation process.

B. Methods

The first physical assembly of the concept was constructed by using nine cardboard ribbons to simulate the blinds, which are individually connected to a crossbar with support of an M6 bolt and nut to make the concept adjustable (fig. 19). In the first concept each blind has to be manually adjusted to simulate a specific mode.
Modes applied in the simulation of the use cases are: the Static Parallel Mode, View Mode and Hide Mode. Three modes, which represent the functionality of the concept simultaneous as they provides maintained functionality during a manual simulation.

To simulate the functionality of the concept compared to a regular Vertical Blind and the properties of the idea, the Static Parallel Mode (see fig. 5) were the first to be initiated, to make the user recognize and feel comfortable with the basic principles found in a Vertical Blind. Presentation of the first mode is followed by instructions of the setup in the View Mode (see fig. 8), easily explained without any technical information to avoid confusion. When instructed, the user is positioned on a rotatable chair with adjusted height in front of the assembly to study the current situation shaped by the ribbons. To simulate the functionality available in a fully functional concept, the ribbons are manually re-adjusted as the user slightly moves.

The Hide Mode is simulated differently with a permanent adjustment of the ribbons, similar to one seen in figure 8, with the permission given to the user to move freely in front of the assembly. Functionality is proven in two different angles, the available vision field and light inlet provided by the sun, in this case simulated with the assistance of a flashlight. With the ribbons adjusted to begin the test, the test subject is located on inside position while different objects are moved along the outside and positioned randomly (see fig. 20). The three simulations are performed for as long as the test subject emits data. When satisfied, the next mode is initiated to continue the simulation.

C. Discussion/Results of validation

When the test subjects first were introduced and informed about the Static Parallel Mode, all of them did react similarly with question; “is this one of those Vertical Blind Curtains?”

As the setup was shaped as a regular Vertical Blind with the parallel relation between the blinds, were the questions about the assembly only a clear confirmation of the integration in the validation process. The Static Parallel Mode did not raise any further questions during the first simulation, due the comprehension as an everyday build by the test subjects.

The second setup, the View Mode, was initiated and adjusted while the subject were blindfolded, still located in front of the assembly since the previous setup. At this point, the five different users evolve a complete unique scenario when interacting with the assembly and the current setup, starting with the Assistant Nurse.

The Assistant Nurse did initially reflect the View Mode as suitable when located in a glass veranda, simultaneously as it works as a regular vertical blind. The general thought that was emphasized, were that it felt complicated.

The Clothes Salesman thought that it was a smart idea as he reflected and observed the construction.

Compared to the previous subjects, the Network Technician was analyzing the setup in a different perspective. He has a major interest in functionality and information of the built, was the possible usage put in a secondary priority. The questions that were asked was though; “Why do I want this?” and –“Isn’t this a sun protection device in the first place?”

The Housewife did response with clear facts; “I’ve got a really clear view and I can look straight in my visual field”. She did finish her sentence with citation; “This would be great in my glass veranda, in a office or in the display windows of a store facing into the street”.

The Senior Citizen, the former barber, didn’t understand the purpose or functionality of the concept at all in the first place. She did immediately response with the statement; “It has to be possible to remove, but why use it when you will achieve more light without the construction?” After a second reflection and longer observation, she pronounced herself; “Hey, I can actually see my environment quite good, but if I see everybody, does that mean that everybody can observe me as well?”

The third and last setup, the Hide Mode, was initiated and adjusted without any blindfolding to make the test subjects experience the completely different effect achieved in the Hide Mode compared to the previous View Mode.

The Assistant Nurse did associate the setup with the current resting room at the hospital, which she experienced to be suitable as a shielding and a better sun protecting device for the inmates compared to the present device used in the hospital.

In comparison to previous mode, the Clothes Salesman evolved a wider response with Hide Mode. He thought it was very useful and would save a great amount of energy as the
sun illuminates the room, at the same time as the sunbeams does not struck you directly in the face. The point of focus of the evaluation was that he never had thought about the vertical blind concept as individual blinds, rather a complete parallel construction. A simple idea that probably would work, smart, smart, really smart as the repeated himself. –“I would like to have a device like this when I watch TV, no sunbeams that interferes with the TV, but the rest of the room stays illuminated without any needs for any additional light sources.”

As in the first test, the Network Technician kept his focus on the technical perspective with a simple question; –“If multiple users entering the recognition area during Hide Mode, will the second and third person be hit by the sun?”

The Housewife did draw the conclusions that the Hide Mode would protect her furniture and other furniture from the bleaching sunbeams, simultaneously as she has the benefits of heat from the sunlight.

The Senior Citizen had a similar experience with the Hide mode as she had with the View Mode. She thought that the idea was a good complement to the parallel vertical blind, but did not get the principles used, with the results that she found the solution unnecessary.

The general object of the test performed, was to measure the main usability features of the concept and test users understandability of the main functions.

The outcome of the test performed was realistic since the participants had different experiences with the test objective in relation to their previous knowledge. And based on the testers personal and professional interest, the results became more diverse with the advantaged of enhanced opinions. By analyzing the understandability of the manual concept, the usability and accuracy can be used to confirm the functionality of the concept. Results are applicable and usable when applied to a final and fully operational concept established in automatic operation mode, ready to operate.

The divergence found in the results when comparing the Assistant Nurse with the Network Technician are highly interesting in this specific case (fig 21), due to the differences in the accuracy aspects. While the Network technician understand the functionality of the concept with the adaption of own interest in the technical functionality, he does not neither identify accuracy nor quality. The Assistant Nurse, which marked no understandability of the functionality in the concept, immediately identified accuracy and quality related to her location at work.

1) Accuracy and Quality
The lack of input considering accuracy and quality in the validation process is related to manual operation used in the first concept. As a manual operation requires the full attention of both the participants and the instructor to simulate the developed modes and scenarios, was not a complete user experience possible to simulate. While the first concept only consists of nine blinds, the linear momentum is constrained by the handful number of blinds, which results in a limited simulation.

With the limitation of speed the blinds are adjusting, the accuracy of the individual adjustment and the momentum provided is resulting in a scenario that is hard to visualize during a single instance of the simulation.

D. Summary
The tests performed with five participants comprehends the perspectives occurred during a day at work as well as time off, to simulate multiple scenarios, with the benefits of both genders presented, the test is based on real life events to expose the prototype as accurate as possible.

To summarize the expressions evolved during the setups, the different professions available had impressions of the results shown in the test. With a widely spread of understandability of the concept, the basic principles were fully understandable at the first interaction.

The second setup, the View Mode, was not as easy to understand without prior explanation. When the setup was explained to the test subjects and studied by them, the ideas started to evolve, all of test subjects except the senior citizen did understand the properties of the mode presented in the concept. This is probably caused by the manual operation of the blind in combination with the facts that the test subjects are not used to an individual adjustment of the blinds. The limited number of blinds used in the test is also a limitation of the validation process, which should be increased in a future full-scale test [13].

The third setup, the Hide Mode, was unexpectedly easier to understand than the View Mode. As the test subjects had the opportunity to observe the adjustment of the blinds, the effects become more efficient when the vision field complete changed over time. When simulated with the assistance of a flashlight to represent the sun, the mode seemed to be more representative and easier to understand during a validation test performed in an experiential environment. As shown in the previous test, the number of blinds used decreased the quality and representation of the test, but fully functional to simulate the functionality available in the concept.
IX. CONCLUSIONS

In this paper, new interaction principles of a vertical blind concept are presented. The interaction modes allow the user to interact with a vertical blind in a completely new way brought by the possibilities of individual controlled blinds. In which ways a concept like the presented one can assist different types of user groups around the world with different physical preconditions, such as disabilities. The individual modes are based on possible use cases and uses to be able to suit real life situations rather than an experimental setup.

A lot of frequent labor-intensive work previously needed to retain a current functionality state of curtains, such as vertical blind used in this thesis, is now eased thanks to this concept. As both a piece of direct functionality of the users interactions and the indirect functions provided to interact with the current weather situation, the concept brings additional features to replace the need for physical operation.

A GUI was developed to adjust the system with the desired functionality. With the use of known interaction models developed by Google and Apple to not interfere with the swipe gestures already known, a basic GUI will help the user to operate through the system settings.

Due to some known limitations, further and experimental modes of the development are excluded and addressed in future work.

X. FUTURE WORK

As the influence of the concept is made by plastic and different types of fabrics to serve different uses or decoration as a part of the style created in the located room. There are experimental fabrics with additional functionality implemented, such as noise absorption [10] and illuminated threads [11], but not available during the development of the ICVB. Possible use for an implementation such as noise absorption fabrics is a tenth mode, the “Noise Mode”, a mode with the task to reduce disturbing noises located outside the window.

Mode 10: The “Noise Mode” uses the properties of the noise absorption fabrics to absorb the noise located outside, by adjust the long side of the blinds facing the highest level of distortion.

<table>
<thead>
<tr>
<th>Number of users:</th>
<th>Insignificant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precondition:</td>
<td>System standby in current mode</td>
</tr>
<tr>
<td>Input:</td>
<td>Noise System</td>
</tr>
<tr>
<td>Action:</td>
<td>Noise of distortion</td>
</tr>
<tr>
<td>Expected response:</td>
<td>When initiated by the user to absorb noise of distortion, the blinds will adjust to absorb as much noise as possible to keep the environmental inside isolated to the noises located outside the window.</td>
</tr>
<tr>
<td>Post condition:</td>
<td>System mode is active and reducing the noise of distortion until the mode is changed.</td>
</tr>
</tbody>
</table>

The possible implementation of a material with such properties is also useable to improve existing modes like Black Out Mode to perform ever better.

We are planning to develop the concept even further and make it possible to implement the modes in a physical concept, ready to serve and assist a potential user in a real life situation on daily basis.

XI. ACKNOWLEDGMENT

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REFERENCES

[6] Svensk elstandard SS 4370146

The T-model
The system boots into the weather screen by default and is ready for immediate user inputs.

“Fast Modes”
The left frame, layer 2, only contains modes available to be applied in a secondary priority.

The right frame contains priority one modes, layer 1. All modes found in the system are available for choosing.